Proceedings of the Tenth International Conference on Urban Pests
Rubén Bueno-Marí, Tomas Montalvo, and Wm. H Robinson (editors) 2022
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BIOECOLOGY OF *CADRA CAUTELLA* (LEPIDOPTERA: PYRALIDAE) UNDER ABIOTIC WAREHOUSE CONDITIONS

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Abstract This research began on December 2018 and ended December 2019, in which the monitoring and weekly review of 4 populations of *Cadra cautella* was conducted. This moth is able to feed from a wide range of different substrates, two sorts of substrate were designed: one based on raw food and the other consisting of a processed one, that is dried fruit and nuts and chocolate tablet and nougat with almonds. *Cadra cautella* can tolerate diverse ranges of temperature and humidity, we fixed the breeding conditions of this scientific experience. Two replicas of each substrate were built, it means four stock populations growing in parallel. The data collected was analyzed and it was observed that the populations of *Cadra cautella* growing on the mixture of nuts have experienced a more vigorous development than those raised with chocolate and almonds, revealing that diet also affects the life cycle and the populations dynamics. Although the abiotic conditions of hours of light and darkness, temperature and relative humidity influence the life cycle by lengthening or shortening its duration and can affect egg hatching, population dynamics is also dependent on the type of food.

Key words Phyticinae, almond moth, cosmopolitan species, biology, economic damages, stored products

INTRODUCTION

The species of the genus Cadra (Walker, 1864) are considered one of the most known stored product pests of the subfamily Pyralidae, and among them stand out the Pyralidae species *Cadra cautella* (Freeman, 1948). This cosmopolitan moth species originally was distributed in the Paleartic region, mainly around the Mediterranean area (Roesler, 1973). However, it was spread because of the human activity to other regions of the world by means of the merchandise transportation of stored products (Horak, 1994). This unfortunate event is of great importance owing to the fact that the mentioned Lepidoptera species is one of the most serious stored product pests that can take place. Indeed, *Cadra cautella* can be found in both domestic and industrial situations feeding on a large range of stored products, from raw ones such as grain, dried fruit and nuts, to processed foods (Horak, 1994).

A biological study of its bioecology under abiotic factors typical of warehouse and homes was carried out to contribute to increase the bioecology information began by other authors in the past (Tuli and Mookherjee, 1963). The main objective of this scientific research was knowing in depth this damaging species to be able to prevent or face its populations to keep them under control, and reduce the economic consequences derived of its natural life-cycle.

MATERIALS AND METHODS

Given that, previous authors had already worked in laboratory conditions with this species (Fukaya, 1939), their works come in handy as inspiration and as a model to follows. The methodology used in the present investigation consisted in designing two different types of nutritional substrates. Finally, and after consulting the published bibliography a raw products and processed food were the substrate prepared. The first one was made up of a mixture of almonds (*Prunus dulcis*), walnuts (*Juglans regia*), pumpkin seeds (*Cucurbita pepo*), pine nut (*Pinus pinea*), sunflower seed (*Helianthus annuus*), raisin (*Ficus carica*), and the second one, was chocolate tablet and nougat with almonds.

Secondly, the controllable abiotic factors of the breeding chambers were set up. The conditions considered were an ambient temperature of ≃ 26.5 ºC, a relative humidity between 35.7 - 46.4% and a photoperiod of 12 hours of darkness and 12 hours of lighting, simulating the sunrise at 08:00 a.m. and the nightfall at 20:00 p.m. Therefore, to carry out the

experimentation, approximately 250 grams of substrate were used in the case of dried fruit and nuts and 500 grams of the processed substrate, where 250 grams were of chocolate and the other 250 grams were of almond. Likewise, both the tray containing the substrate and the specimens of the population of *Cadra cautella* were deposited inside square entomological boxes which dimensions were 23.5 centimeters wide x 23.5 centimeters high x 23.5 centimeters deep. In this way, the four populations were subjected to the same factors of space, food availability and environmental conditions. Thirdly, the monitoring was based on a weekly review of the four populations. The process required the counting of every single specimen either in its caterpillar, chrysalis or imago state.

To confirm that the specimens used in the experimentation were unequivocally *Cadra cautella*, it were used the taxonomic characteristics descriptions of this pyralid from Horak (1994). In the same way, and since its external identification is complicated, it was necessary to resort to the internal genitalia study.

RESULTS AND DISCUSSION

The weekly revision of the four stock of *Cadra cautella*, have provide a huge volume of data. After analyzing them, the bioecology of this species has been shown and the results are as follow.

In the case of *Cadra cautella* growing in dried fruit and nuts de patron of vital cycle is similar in both replicas. In the first case, and focusing on the larva phase, it is observed that the population size, once they have acclimatized perfectly to the mentioned conditions, increase exponentially from December to March. It then experiences considerable growth in a short period of time between March and May where it reaches the maximum peak of growth coinciding with the spring season. Then, the growth falls slightly and remains until August coinciding with the summer season. Between August and September, it undergoes a drastic decrease in the larval population size and, from this moment until the end of the year, it is observed how it increases again exponentially during the autumn months. Regarding the state of chrysalis or pupa, the population growth curve is very similar to that of the larva state, although it presents a logical delay in the appearance of the peak of sudden increase that in this case occurred in April instead of in May. Moreover, when it comes to adult status, they show a similar dynamic, although with more marked differences between the different months. However, the peaks of sudden growth of the maximum number of individuals and the drastic decline coincide with those of the other two phases of their development (Figure 1). In the second stock of this type of substrate, one would expect a similar if not identical dynamic. However, this shows two peaks of maximum number of individuals in larval state, one in the winter season, specifically in February and the second in spring, particularly in May. In the case of pupae, the existence of two points of maximum appearance of individuals is repeated again, but in this case the first one occurred in March, with a month of delay as it happened in the first stock and, the second in May. In the case of the adults, again two peaks of increase of the number of specimens are appreciated, one in March and another in May. A notable event in this second stock is that after the decline of the three states of development, the populations remain at a baseline level where growth is barely appreciated (Figure 1).

Regarding the results of the second type of nutritious substrate, in the first stock larvae show a succession of considerable ups and downs both in the number of specimens that perish and in which they hatch. Therefore, in this case repeated peaks are observed where the larval population is high, these being in January, March, July, and September. Which does not obey any seasonality as if it was appreciated in the first type of substrate that would be related to the biological cycle of the nutritious plant. On the other hand, the pupae show three clearly differentiated peaks, the first in March, the second between June and July and the third in September, the last being the highest. Adults, however, show the three peaks in May, September and December, the next peak being successively higher than the previous one (Figure 2). In the second stock, the larvae show a very high mortality peak in the first months of experimentation, which leads them to think that it took them more than expected to acclimatize to the new conditions. However, it subsequently shows a peak of population growth between the months of June and July and a similar one in September. The pupae on the other hand reveal having exhibited several points of population growth, two of them in the winter months of January and March, a second between the summer months June and July and one last in September, coinciding with the arrival of autumn. Finally, the adult state shows three small peaks, the first being again in January, the second in July and the third in September. In this last replica, it should be noted that the population collapsed between the months of October and November, depending on the state of development (Figure 2).

It can be affirmed that the type of substrate on which *Cadra cautella* feeds has effects on its life cycle. Note that, when it feeds on a varied food source, its population sizes are higher than those populations that feed on a single type of food. Therefore, the wide diversity of proteins, minerals, sugars and fatty acids present in the first case has

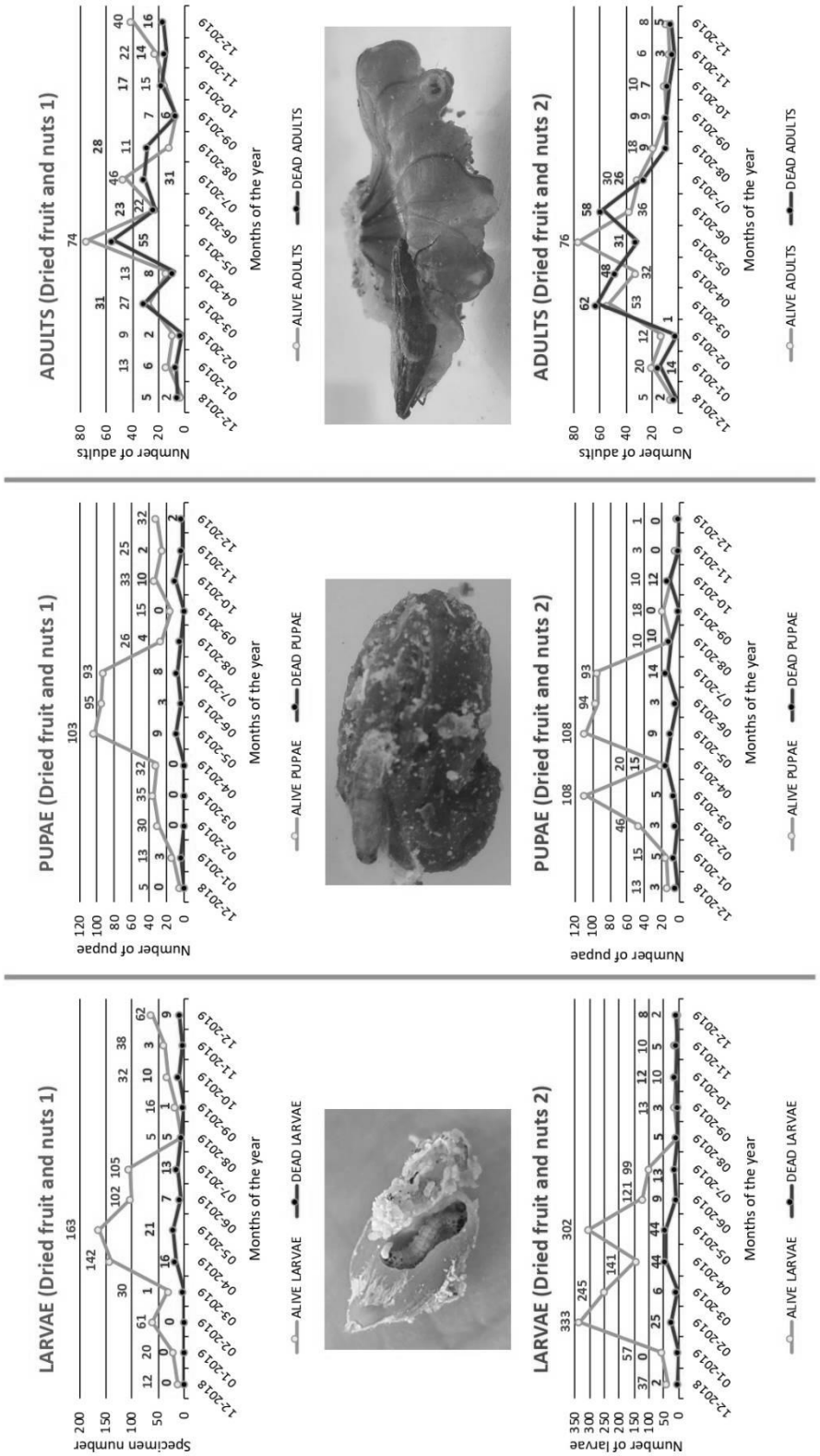

Figure 1. *Cadra cautella* populations raised with dried fruit and nuts as a food substrate.

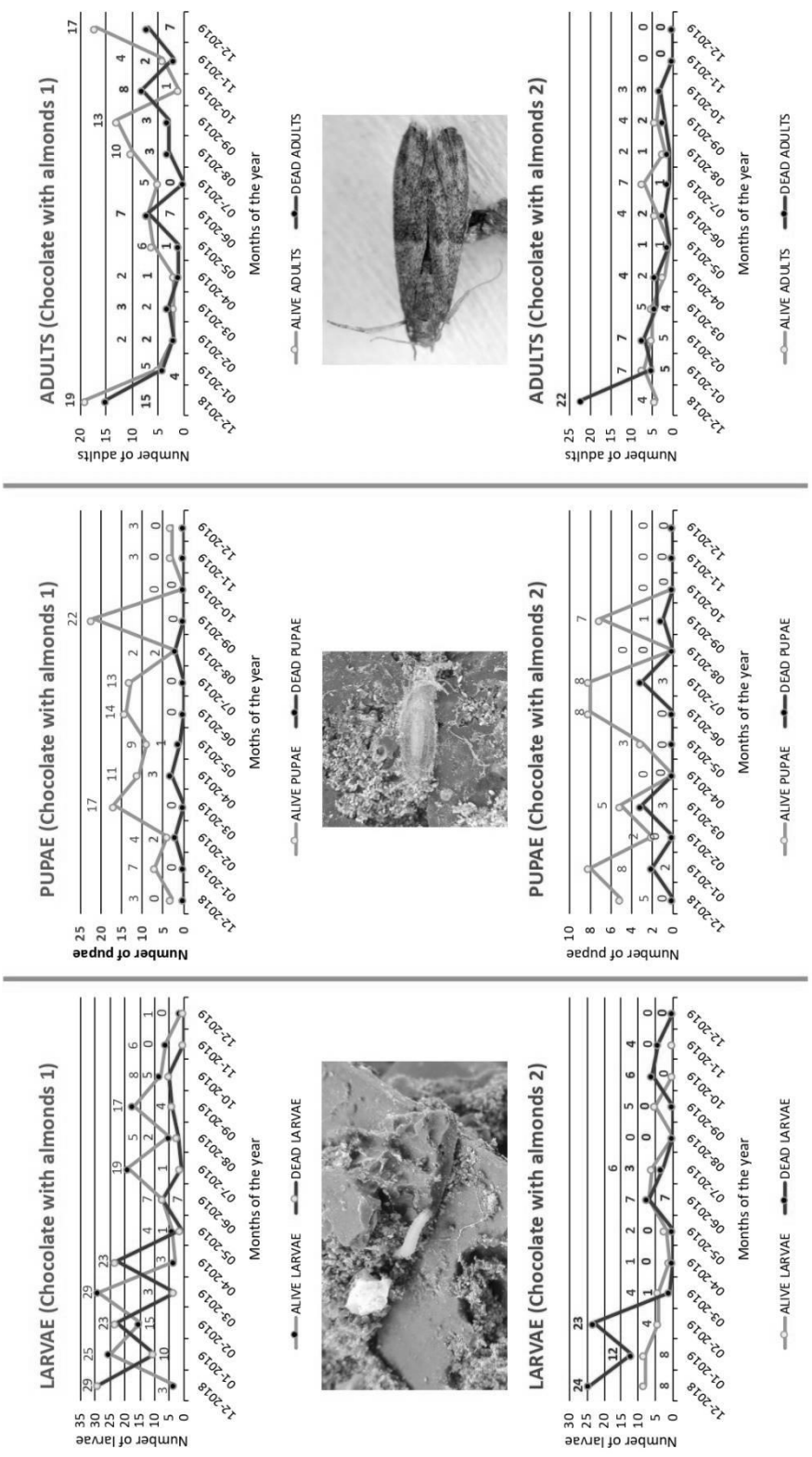

Figure 2: *Cadra cautella* populations raised with a substrate of chocolate and almonds.

played a crucial role in the size reached by the population and its continuity, since they had a very complete diet. However, in the case of processed products, it has been observed that larvae have barely fed on the source of fats and sugars from chocolate, but that they have only obtained their source of energy from a single type of food, almonds. As a result, this situation has conditioned both population sizes and their complete disappearance when suffering from a deficit of essential amino acids because of a poor diet. In addition, due to this circumstance, the life expectancy of the population varies widely between the two types of substrates on which the present investigation has been carried out.

The environmental conditions in which an individual is reared can have profound effects on its development, adult morphology and reproduction power. For instance, at high densities the developing juveniles often exhibit predictable declines in body size and fecundity and increases in developmental duration and adult longevity (Peters and Barbosa, 1977). These differences in the juvenile environment may affect adult reproductive strategy (Demary and Lewis, 2007). The variation in population size at the larval phase has profound fitness consequences for both sexes (Gage, 1995; McNamara et al., 2010). The population density can affect the power of the reproduction of the almond moth (Takahashi, 1961).

CONCLUSIONS

For all the exposed reasons that consider *Cadra cautella* a serious worldwide level crops pest, both in the field and in storehouses, this research was necessary. In addition, the infestation by the populations of this moth considered pest, represents a triggering of economic loss since it significantly limits the sale and keeping the export dates. It can be said that under controlled hours of light and darkness, temperature and relative humidity, the life cycle of *Cadra cautella* is influenced by the type of food from which they feed, lengthening and/or shortening both, its duration and population dynamics.

ACKNOWLEDGMENTS

I would like to show my most sincere gratitude to everyone who have given me a hand, without whom this project could not have been carried out.

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